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E. WOLF

3,301,237

TWO-STROKE INTERNAL-COMBUSTION ENGINE

Filed July 3, 1964

4 Sheets-Sheet 1

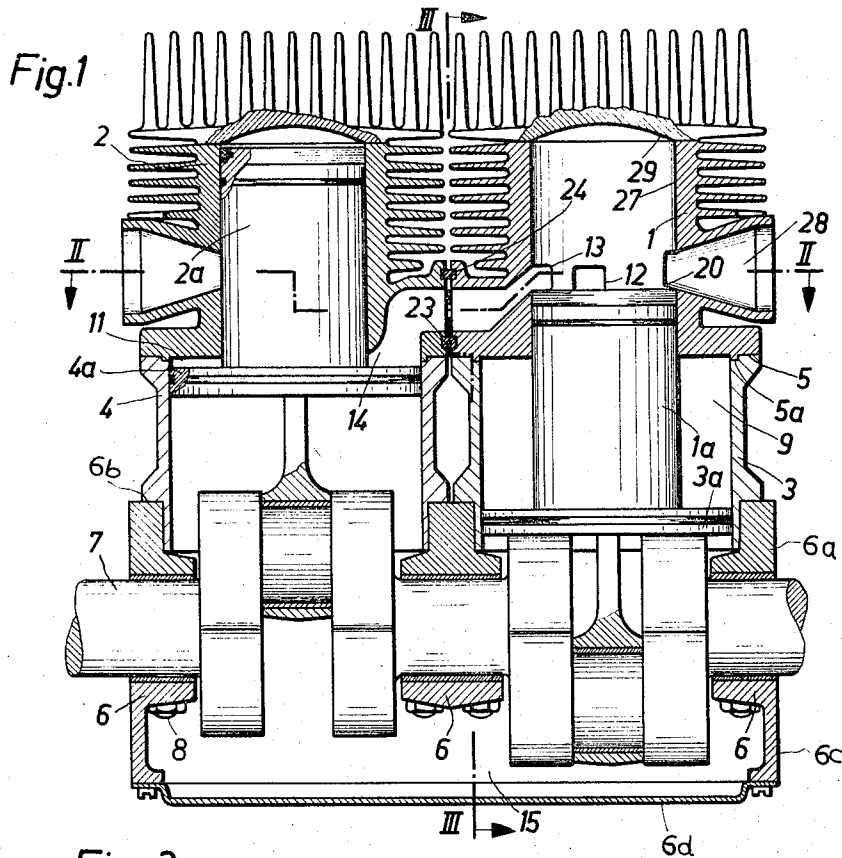
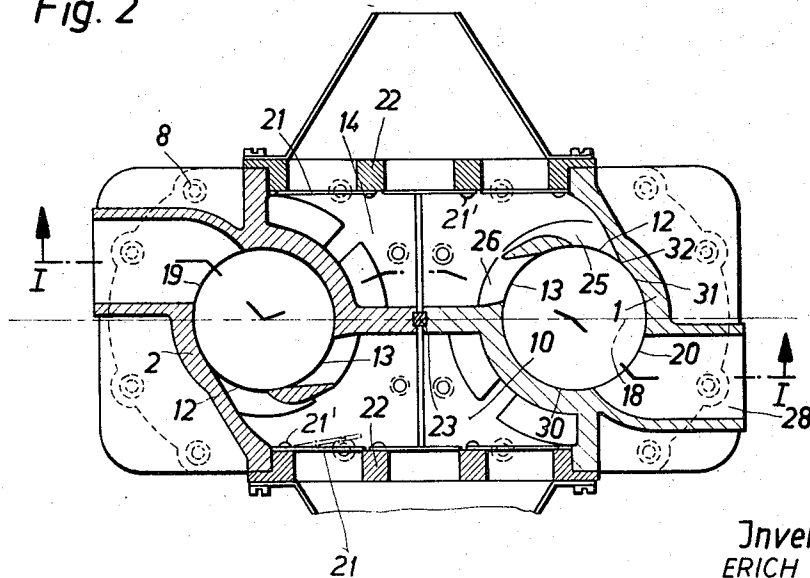


Fig. 2



Inventor:
ERICH WOLF

Karl J. Ross
AGENT

Jan. 31, 1967

E. WOLF

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Fig.3

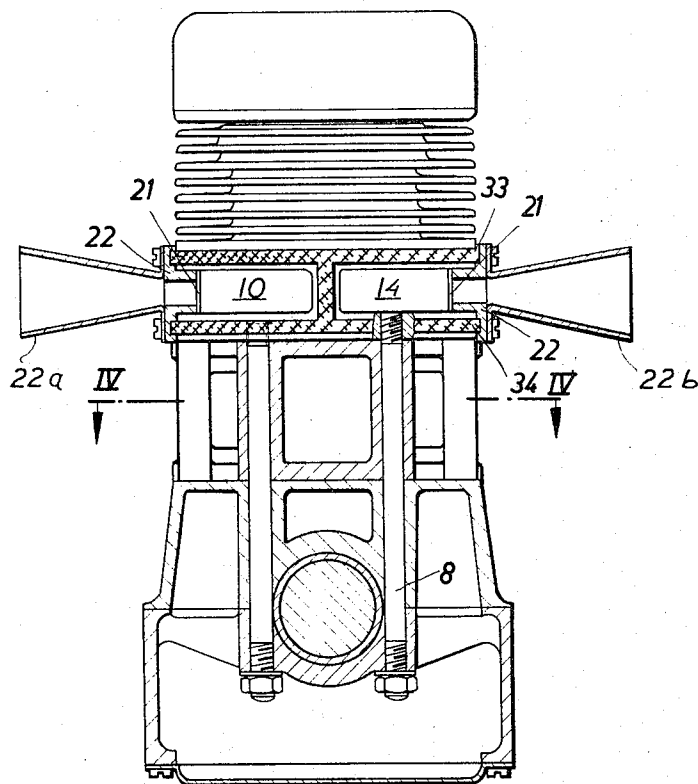
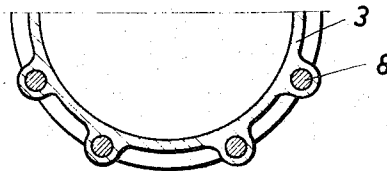


Fig.4



Inventor:
ERICH WOLF

Karl F. Rose
AGENT

Jan. 31, 1967

E. WOLF

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Fig. 3A

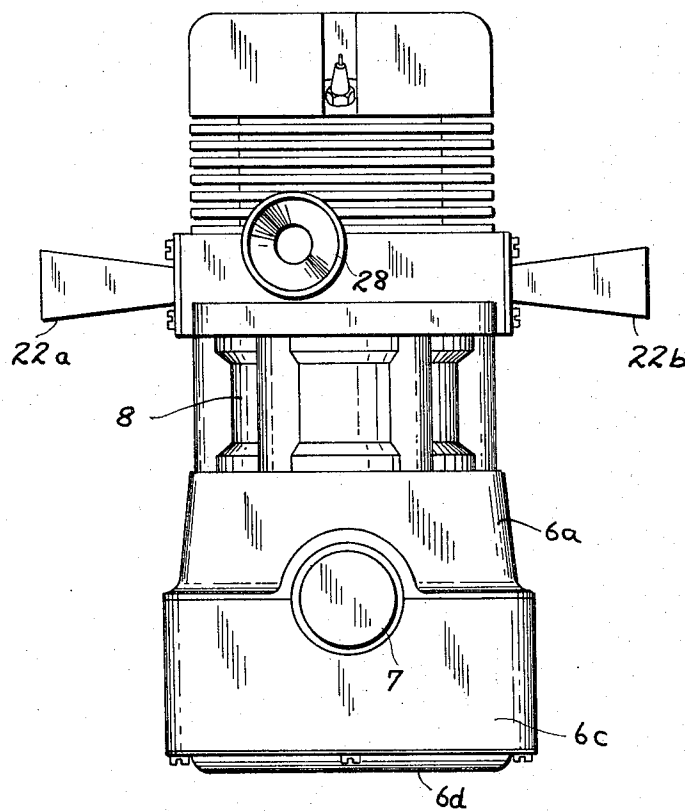
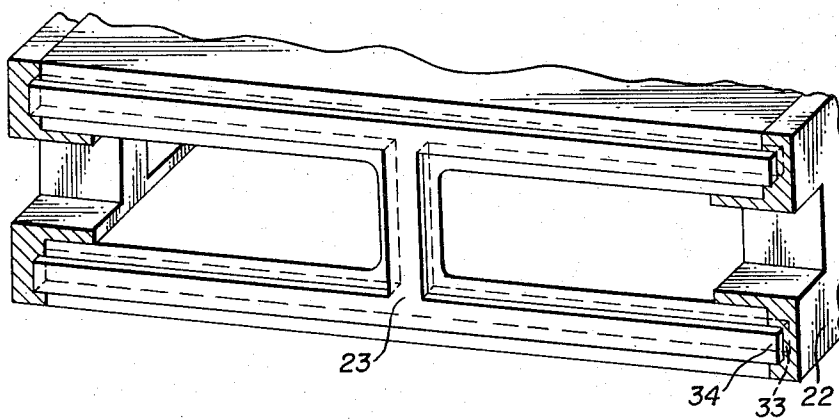


Fig. 5



INVENTOR
ERICH WOLF

Karl F. Ross
AGENT

Jan. 31, 1967

E. WOLF

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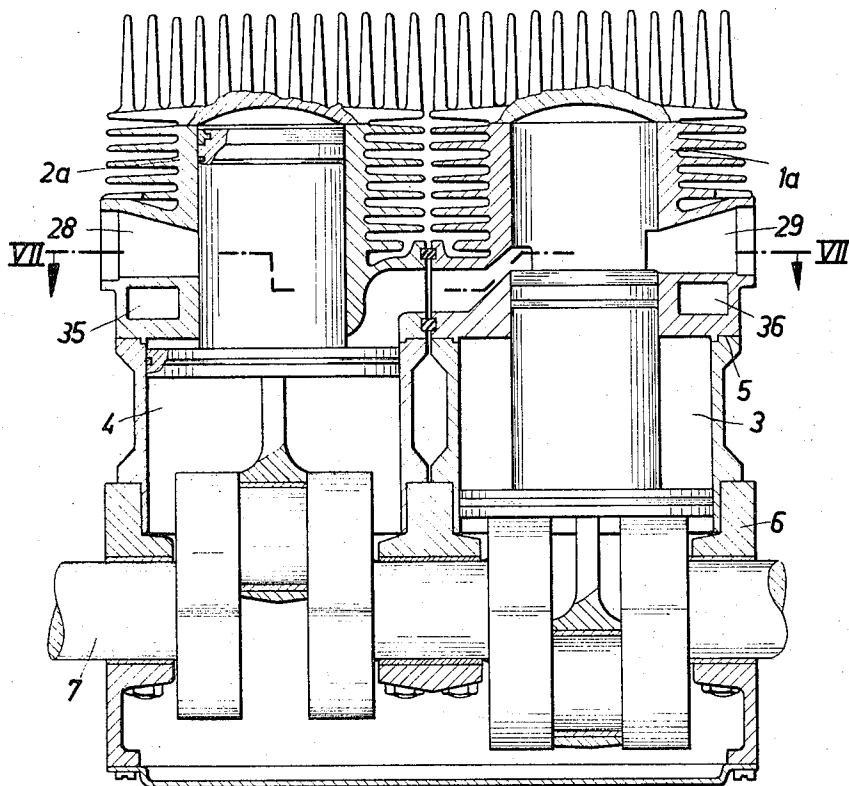


Fig. 6

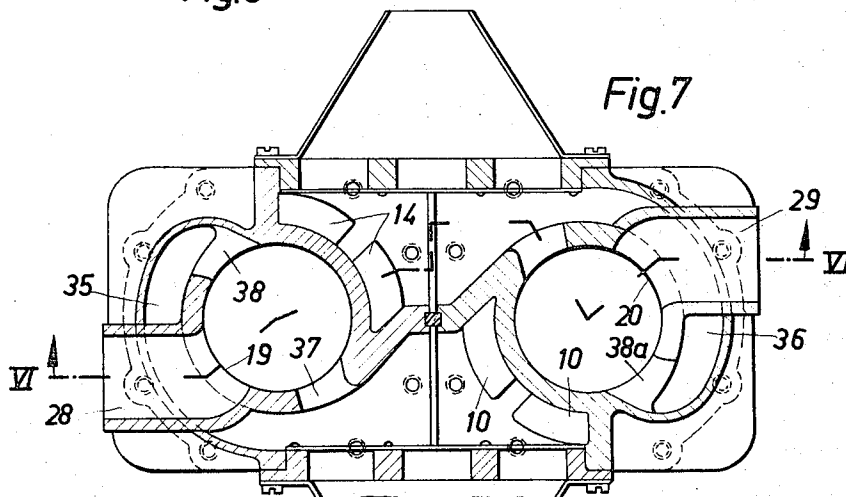


Fig. 7

Inventor:
ERICH WOLF

Karl F. Ross
AGENT

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3,301,237

TWO-STROKE INTERNAL-COMBUSTION ENGINE

Erich Wolf, Wiesbaden, Germany, assignor to Zweirad-Union A.G., Nurnberg, Germany, a corporation of Germany

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Z 10,211

8 Claims. (Cl. 123—71)

My present invention relates to two-stroke or two-cycle internal-combustion engines and, more particularly, to engines of this general type wherein the power-output pistons are provided with a compression step for pressurizing the scavenger fluid and displacing it through the power cylinder to purge therefrom exhaust gases and, usually, to supply a fresh fuel mixture.

It is a common practice in the art of two-stroke-cycle engines to provide the operating or power piston or pistons with a surface adapted to compress the scavenging fluid during the downstroke of the piston so that the scavenging fluid (which can be a fuel-air mixture) can be admitted into the corresponding cylinder or the cylinder of another piston under some pressure. In this case, the compression surface of the piston, which may merely serve to reduce the volume of a crankcase space to which the scavenging fluid is admitted, replaces auxiliary compressors or the like whose function it is to supply the fuel/air and scavenging mixture under a pressure sufficient to permit the fluid to sweep substantially all of the exhaust gases from the cylinder in which a firing has occurred. Originally, the piston was provided with a single step and had, therefore, an effective surface of substantially constant diameter exposed to the gases in the cylinder and thus in the crankcase. It is possible, however, to provide the pistons with an additional step, whose diameter may be larger than that of the working piston to increase the volume of scavenging fluid compressed during each stroke, the fluid-compression piston being displaceable in a pumping cylinder. The present invention is directed to improvements in two-cycle engines of the latter type.

For the most part, dual-piston assemblies (i.e. stepped-piston arrangements wherein a working piston and a pumping piston are integral or mounted for joint displacement on a common piston rod) have not found widespread acceptance because of the fact that it was difficult to construct the working and pumping cylinders in an integral engine block in such manner that their center lines coincided precisely. If such accurate alignment was not observed, one of the two piston surfaces of the dual piston failed to run concentrically in the respective cylinder bore. The result was a high wear of the piston, its rings and/or the wall of the cylinder bore.

It is the principal object of the present invention to provide a two-stroke-cycle engine in which the aforementioned disadvantages can be avoided.

A more specific object of this invention is to provide a two-stroke engine wherein a dual piston having a jointly displaceable working piston and a pumping piston can be used without difficulties arising from misalignment of the respective cylinder bores.

Yet a further object of the present invention is to provide a two-stroke engine of a relatively simply and inexpensive construction capable of obtaining high engine efficiencies.

The above and other objects which will become apparent hereinafter are attained, in accordance with the present invention, by providing a two-stroke engine of the general character described wherein a dual-piston assembly has its working piston and its pumping piston rigidly interconnected in axial alignment and displaceable in respective bores of a cylinder block which is subdivided into a first portion formed with the working cylinder and a second portion formed with the pumping cylinder, the two separate portions being connected together by fastening means and adjoining substantially at the junction of said pumping cylinder and the working cylinder which is axially aligned and communicates therewith. Thus, the two portions of the cylinder block about one another along a line of separation substantially in a plane perpendicular to the common axis of the cylinder bores and pistons at the point at which the large-diameter pumping cylinder communicates with the small-diameter working cylinder. It will be apparent that the fastening means interconnecting the two parts of the cylinder block are tightened only when the two cylinder bores are in true axial alignment. In general, two cylinder block assemblies or sections of this character will be provided for the engine with passages connecting the scavenging-fluid pumping cylinder of one section of the engine block with the working cylinder of the other. The two sections of the first and second portions of the engine block can also be separate from one another and connected by means of the fastening means mentioned above with the two portions of each section having the working and pumping cylinders in axial alignment. This system has an advantage over prior engine constructions making use of a plurality of interconnected cylinder-block parts in that the numerous alignment formations and locating surfaces can be eliminated. In these structures, it was difficult to insure proper alignment of the cylinder parts as well as of the bearings for the crankshaft.

While it is desirable to insure that the first portion of each section of the engine block (i.e. the parts provided with the working cylinder) should about the respective second portion of each section in a plane with the fastening means extending perpendicularly to this plane, it is desirable to provide an annular centering formation on the first portions adapted to fit into a respective annular recess in the wall of the pumping cylinder of the respective second portion for locating the corresponding working and pumping cylinders in proper axial alignment. Moreover, it is desirable that the fastening means mentioned above bridge the first portions of the cylinder block and a main-bearing carrier for the crankshaft, the fastening means being disposed outwardly of the pumping cylinders. The fastening means (e.g. bolts) are disposed in the proximity of the main bearings, preferably with at least two bolts on opposite sides of the crankshaft, and in a plane of the main bearings perpendicular to the crankshaft. In this case, the crankcase walls do not carry the load of the crankshaft and serve merely to enclose the crankshaft and the connecting-rod bearings of the crank drive.

It is another important feature of the present invention that the first and second portions of both sections of the engine block be identical with the corresponding member of the other section and so arranged that they are symmetrical about the vertical centerline of the engine. In this case, the first portions and the second portions of each section can be interchanged as desired and only a single configuration of each member need be produced. More specifically, it is desirable that the working cylinder of one section be provided with scavenging ports or slots communicating with the pump cylinder of the other section while the pump cylinder of the first section communicates with the scavenging or inlet ports of the other section; both of the pump cylinders can be open to the interior of the crankcase below the respective pumping pistons. While, as mentioned above, the crankcase in conventional two-cycle engines communicated with the compression space into which the scavenging fluid was drawn and from which it was supplied to the working cylinders, in the engine of the present invention the compression space for the scavenging fluid is separated from

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the crankcase by the pumping piston. Lubrication of the engine can then be effected by the techniques normally used in four-cycle engines.

Using this arrangement, it is possible to exploit an integral crankshaft and bearing assembly and insure that sufficient scavenging air and the desired pressure is supplied to the working cylinders without the disadvantages of having the mixture first passed through the crankcase. The interchangeability of the several parts of the engine can be insured in several ways. In one case, preferably two circumferentially elongated scavenging ports are provided in the working cylinder on one section on one side of the vertical median axial plane of the cylinders while two corresponding scavenging ports are provided in the working cylinder of the other section on the opposite side of this plane. These ports communicate with respective ducts connecting them to the pumping cylinders of the other section, these ducts each being provided with a membrane-type unidirectional valve admitting the scavenging mixture to the respective duct on the downstroke of the respective pumping piston. The membrane-type valve can also be identical and disposed symmetrically on opposite sides of the median plane. Thus the two piston assemblies, working cylinders, pumping cylinders and valve means are identical with one another and interchangeable.

It is still another feature of this invention to provide the first portions of each section with registering lateral openings on each side of the median plane, these lateral openings forming the scavenging ducts and being closed by apertured lateral plates on whose inner surfaces are provided the membranes forming the valve. The ducts on opposite sides of the median plane are separated from one another by sealing means which, moreover, at least partially surrounds the apertures through which the registering openings forming each duct communicate with one another. For this purpose, the two first portions can have juxtaposed inner faces formed with registering grooves surrounding the apertures and adapted to receive a sealing element which can bridge the grooves of the juxtaposed faces.

It is also possible, according to this invention, to space the two scavenging ports of each working cylinder angularly about the axis of the respective working cylinder and provide the corresponding duct with a transfer channel interconnecting the two scavenging ports. Advantageously, the transfer channel extends transversely of the respective exhaust port and underlies the latter in heat-exchanging relationship therewith so that the scavenging fuel/air mixture is heated by the sensible heat present at the exhaust port before it is introduced into the cylinder. This also serves to cool the cylinder wall in the region of the exhaust port and to reduce wear and deterioration thereof.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a vertical cross-sectional view taken along the line I—I of FIG. 2 showing a two-cylinder, two-stroke engine according to the present invention;

FIG. 2 is a cross-sectional view taken along the line II—II in FIG. 1;

FIG. 3 is a cross-sectional view taken along the line III—III in FIG. 1;

FIG. 3A is an end-elevational view of the engine;

FIG. 4 is a cross-sectional view taken along the line IV—IV of FIG. 3;

FIG. 5 is a perspective view, partly in section, of the sealing means between the two sections of the engine block;

FIG. 6 is a view similar to FIG. 1 taken along the line VI—VI of FIG. 7; and

FIG. 7 is a cross-sectional view taken along the line VII—VII of FIG. 6.

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In FIGS. 1-5, I show a two-cylinder, two-stroke engine in which the cylinder assembly or engine block is formed in two sections each corresponding to one cylinder of the engine. The working cylinders or first portions 1, 2 are separated from the second portion 3, 4 provided with the respective pumping cylinders by means of separating junctions 5. The working cylinders 1, 2 support the main-bearing carrier 6 for the crankshaft 7, via bolts 8 (FIGS. 2-4) lying outwardly of the pumping cylinders 3, 4 and preferably passing through bosses or ribs axially extending along the periphery thereof (FIGS. 3A and 4). The working compartment 9 of pump cylinder 3 is separated from the crankcase by the pump piston 3a and is connected via a scavenging duct 10 (FIG. 2) with the scavenging ports 12 and 13 angularly offset about the axis of working cylinder 2 and opening into the latter. Similarly, the working compartment 11 of pump cylinder 4 is separated from the crankcase 15 by the piston step 4a and connects via the scavenging duct 14 (FIGS. 1 and 2) with the scavenging ports 12, 13 of the working cylinder 1 of the other engine section. The pump cylinders 3, 4 open at their bottoms into the interior of the crankcase 15. Both scavenging ports 12, 13 of the working cylinder 2 lie on one side of the vertical common axial plane 18 of the working cylinders, i.e., to the left of this plane when viewing FIG. 2 from the right-hand side; the scavenging ports 12, 13 of the other working cylinder (cylinder 1) lie to the right of the axial plane 18 when viewed in the same direction. Similarly, the exhaust port 19 of cylinder 2 and the exhaust port 20 of cylinder 1 lie to the right and left, respectively, of plane 18. It will thus be apparent that the engine is substantially symmetrical with respect to a vertical center-line lying in plane 18 and extending parallel to the axis of cylinders 1 and 2 midway therebetween. Each of the scavenging ducts 10, 14 is formed by registering openings of the cylinders 1, 2 and are, moreover, open laterally at respective membrane valves 21, which permit the scavenging and fuel mixture to be drawn into the cylinders via the ducts 22a, 22b. The mixture can be supplied in a conventional manner by a carburetor or gasifying device. The lateral openings of the ducts 10, 14 are provided with valve plates 22 to which the membranes 21 are fastened by screws or rivets 21' (FIG. 2) to enable the resilient membranes 21 to deflect inwardly upon the development of a reduced pressure in the respective duct.

Since the working cylinders 1 and 2 are individually mounted upon the independent pumping portions 3, 4 and are spaced apart at their abutting faces at which the respective apertures of the ducts 10 and 14 register, I provide a sealing member between two cylinder portions 1, 2. The sealing means includes an H-shaped channel 24 (see FIGS. 1, 3, 5 especially) in which a resilient sealing member 23 of similar configuration is received. This sealing member projects from one groove into the registering complementary groove into the other cylinder portion and is of a sufficient thickness to bridge the cylinders 1 and 2 and be compressed when the fastening bolts 8 are tightened. The elasticity of the resilient seal 23 is thus sufficient to fill any gap between the working cylinders 1 and 2 around the scavenging ducts 10 and 14. The arms 34 (FIG. 5) of the sealing element 23 extend laterally beyond the cylinders 1, 2 and are received in recesses 33 of the valve plates 22 (see also FIG. 3). While it is preferred that the sealing element 23 be received in the grooves 24 with no play and indeed that it be held against the walls of these grooves under pressure upon tightening of the fastening bolts 8, it is also possible, in accordance with the present invention, to permit the sealing element 23 to have some play in the grooves. In this case, the development of a reduced pressure in duct 10 or 14 will draw the sealing member against the inner wall of the grooves surrounding each duct while the development of an elevated pressure during the pump-

compression stroke will force the sealing member against the outer wall of each groove 24.

The outlets 25 and 26 of the scavenging ducts 10 and 14 at the respective ports 12, 13 are directed tangentially upwardly against the walls 27 (FIG. 1) above the respective exhaust port 20. The scavenging fluid thus streams along this wall in the form of a vortex or spiral upwardly into the cylinder head 29 to form a sheet of scavenging air communicating with a downward central flow which passes out through the exhaust port 19 or 20. The suction of the exhaust duct 28 (FIGS. 1 and 2) communicating with each exhaust port 19 or 20 is effective in the interior or central portion of each cylinder and along a one-apertured side cylinder zone 30. It will thus be evident that the effectiveness of the scavenging stream is not diminished by the presence of the exhaust ports and that this stream sustains very little loss through the exhaust ports in the manner of conventional two-stroke engines. Opposite the relatively wide cylinder zone 30 there is a narrower zone 31 which extends from the end of the scavenging port 12 (edge 32) to the exhaust port 20. The width of this narrower zone is so chosen that the scavenging stream leaving ports 12 and 13 can rise to the wall 27 above the exhaust port without being intercepted by the suction of the exhaust port.

It will be evident that the cylinder portions 1 and 2 are identical to one another and interchangeable as are the pumping cylinders 3, 4 and the pistons 1a, 3a and 2a, 4a. The working cylinders 1 and 2 are centered on their respective pumping cylinders 3, 4 via annular centering formations 5a extending transversely to the abutting surfaces of the working and pumping cylinders and received in complementary recesses at the upper edge of the pumping cylinders 3, 4. Upon tightening of the bolts 8, the working cylinders 1, 2 are rigidly fixed to their respective pumping cylinders 3, 4.

The engine operates substantially as follows:

When the piston 2a, 4a begins its downstroke from its position illustrated in FIG. 1, the working chamber 11 of pumping cylinder 4 expands and a scavenging fluid is introduced into this chamber via duct 14 and the respective membrane valves 21. Approximately in the region of its lower dead-center position, the piston 2a, 4a no longer descends sufficiently to draw additional scavenging fluid into the duct so that the membrane springs 21 close. During the ascending stroke of the piston 2a, the pumping piston 4a reduces the volume of the working compartment 11 and compresses the scavenging fluid. Meanwhile, the piston 1a, which has during the initial compression of the fluid in compartment 11 blocked the scavenging ports 12, 13 of cylinder 1, descends sufficiently so that its upper edge clears these slots (FIG. 1) and the scavenging fluid spirals upwardly in the cylinder 1. The exhaust suction is effective along cylinder zone 30 while the scavenging air clears the cylinder wall above the exhaust port. As the working piston 1a rises, it closes the scavenging ports 12, 13 and compresses the fluid therein. The firing and power stroke then occurs via the usual spark plug (FIG. 3a). In a corresponding manner, the scavenging and charging of the other working cylinder 2 is effected with the scavenging fluid deriving from the compartment 9 of pump cylinder 3. The lubrication of the apparatus can take place via the lubricating means common to conventional four-stroke engines.

In FIGS. 6 and 7 I show a modification of the system of FIGS. 1-5 wherein the pumping cylinders 3, 4 and other parts which are identical to those of FIGS. 1-5 have been indicated with the same reference numerals. It should be noted that, in both cases, the main-bearing support 6 is subdivided into an upper and a lower portion, the upper portion being designated by the reference numeral 6a. The pumping cylinders 3, 4 are mounted upon seats 6b of this upper member 6a while the lower member 6c, to which the oil pan 6d is attached, is clamped about the crankshaft 7 by the bolts 8. In FIGS. 6 and 7,

however, a modified construction of the working cylinders 1a, 2a is used although both form an abutting junction at 5 with the pumping cylinders 3 and 4. The cylinders 1a, 2a are again provided with the scavenging ducts 10 and 14 having membrane-type unidirectional valves identical to those illustrated at 21 in FIGS. 1-5. The ducts 10 and 14, however, have their scavenging ports 37, 38 and 37a, 38a spaced apart about the axis of the respective cylinder by substantially 180°. Thus the scavenging ports 38 and 38a communicate with transfer channels 35 and 36 which are integral with the cylinder walls but pass beneath the exhaust ducts 28, 29. In this case, the exhaust ducts 28, 29 are juxtaposed with the broad unapertured wall of the respective cylinder below which the ducts 10 and 14 open into the respective pumping chambers. The scavenging ports 37, 38 and 37a, 38a are disposed on opposite sides of the exhaust ports 19, 20. In operation, the engine of FIGS. 6 and 7 functions similarly to that of FIGS. 1-5. The scavenging of the cylinders is, however, somewhat different. From the scavenging ports 37 and 37a, a tangentially and upwardly directed stream of scavenging fluid forms a spiral shell along the cylinder wall. In this case, the unapertured surface of the wall is not swept by an exhaust stream but by a scavenging stream under pressure from the scavenging ports 38 and 38a. Since the scavenging fluid is somewhat cooler than the exhaust gases, it picks up sensible heat in the region of the exhaust ducts 28, 29, thereby cooling the wall of the cylinder in the region of these ducts and reducing deterioration of the cylinder wall especially in the region of the exhaust ports 19, 20. Moreover, the combustibility of the fuel/air mixture is improved by the heat derived from the exhaust gases even after compression of the mixture within the cylinder. The cooling of the cylinder wall and exhaust duct is even more pronounced when the engine is provided with a carburetor since then the sensible heat is exploited in part to vaporize droplets of fuel in the gas mixture. This utilization of heat permits the gas stream to absorb substantially higher amounts of thermal energy.

The invention as described and illustrated is believed to admit of many modifications and variations within the ability of persons skilled in the art, all such modifications and variations being deemed to be included within the spirit and scope of the appended claims.

I claim:

1. In a two-stroke internal-combustion engine having an engine block with a pair of working cylinders each coaxially aligned with a respective pumping cylinder, a respective stepped piston reciprocable in each of said working cylinders and the associated pumping cylinder whereby said pistons each force scavenging air from the respective pumping cylinder into the working cylinder of the other piston, and crankshaft means connecting said piston for synchronized movement, the improvement wherein:

said engine block comprises

a pair of substantially identical block portions each provided with a respective one of said working cylinders, an exhaust port, and intake and scavenging ports opposite said exhaust port, the intake port and scavenging port of one of said block portions opening directly toward and respectively juxtaposed with the scavenging port and intake port of the other block portion, and

spacer means interposed between said block portions for sealingly and spacedly interconnecting same at said scavenging and intake ports while forming respective passages communicating between each scavenging port and the intake port of the other block portion.

2. An engine as defined in claim 1 wherein the first-mentioned block portions are coaxially aligned with respective second portions of the block formed with the respective pumping cylinder, said first and second portions of each of said sections abutting in a junction lying gen-

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erally in a plane perpendicular to the axis of the respective cylinders, each pair of first and second block portions forming a respective engine section, one of said portions of each section having an annular formation surrounding its cylinder and receivable in a complementary recess of the respective section, said formations extending transversely to the plane of the respective junction.

3. An engine as defined in claim 2, further comprising common bearing-support means connected with both of said sections and a crankshaft journaled in said bearing-support means and operably connected with both of said dual-piston means, said fastening means including a plurality of bolts for drawing said first portions and said bearing-support means together and clamping the respective second portions between said first portions and said bearing-support means, said bolts extending parallel to the axes of said cylinders externally of said pumping cylinder.

4. An engine as defined in claim 2, further comprising a crankcase disposed below said pumping cylinders and communicating therewith, said pistons each subdividing the respective pumping cylinder into a working compartment proximal to the respective working cylinder and a further compartment opening into said crankcase.

5. An engine as defined in claim 4 wherein both of the scavenging ports of each working cylinder are disposed on a side of a common medium axial plane of said cylinders opposite that on which the scavenging ports of the other working cylinder are provided, said exhaust ports being located on opposite sides of said axial plane.

6. An engine as defined in claim 5 further comprising membrane-type valve means laterally closing said ducts

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for admitting fluid thereto but blocking the escape of fluid therefrom.

7. An engine as defined in claim 5 wherein said scavenging ports of each working cylinder are tangentially upwardly directed against a wall of their cylinder above the respective exhaust port for generating a spiral flow of scavenging fluid along the wall of said working cylinders, said exhaust ports being adapted to draw air along at least a portion of the wall of said working cylinders.

8. An engine as defined in claim 5 wherein said first portions are each provided with a transfer channel connecting a respective duct with one of the scavenging ports communicating therewith, said transfer channel passing proximal to the exhaust port of the respective working cylinder.

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MARK NEWMAN, *Primary Examiner.*

WENDELL E. BURNS, *Examiner.*

Dedication

3,301,237.—*Erich Wolf*, Wiesbaden, Germany. TWO-STROKE INTERNAL-COMBUSTION ENGINE. Patent dated Jan. 31, 1967. Dedication filed Nov. 29, 1972, by the assignee, *Zweirad-Union AG*.

Hereby dedicates to the Public the entire term of said patent.

[*Official Gazette March 13, 1973.*]